imagery to combine multiple data types into a single display that retains the information of the individual data sets and shows how they interact. Wentland thus describes a basic processing and display tool such as VoxelGeo and Gocad. Briefly stated, in Applicants' method, effective realization of regions (or subsets) within the data set during interpretation is improved through interactive modification of region constraints, displayed opacity, or displayed color scale. Applicants' method could be used in conjunction with a general software tool such as Wentland's method to effectively and efficiently manage multiple regions. Alternatively, Applicants' method can be used independently, and further is not limited to use with seismic data. Neither Wentland's method, nor any other similar general tool of which Applicants are aware, includes a module similar to or suggestive of Applicants' invention.

Attention is directed to the last paragraph in the Background section of the present application, where the technical problem is defined. That paragraph is repeated here for convenience:

"Currently, to identify regions of interest (such as, regions constrained by horizons or faults of interest) in seismic volumes requires a time-consuming processing step to "sculpt" the data volumes. Sculpting currently requires use of individual bits to control the processing or rendering of a region. Combining multiple constraints (such as horizons or faults) requires the reprocessing of the entire volume using Boolean-logic to individually check each region's constraint. Modifying region constraints or creating regions based on the combination of multiple constraints, with current technology, requires vast amounts of computational resources, especially in large three-dimensional data sets. Accordingly, there is a need for an efficient and flexible way to interactively handle regions defined by multiple constraints and to apply Boolean-logic to these regions for interpretation and visualization applications."

Applicants' invention satisfies this need. Moreover, it will be demonstrated below that Wentland's method is but an example of the existing state of the art as described in the preceding paragraph, in regard to its sculpting capability. The term "region" as used in the present application can be related to Wentland's terminology. Wentland appears to use "objects" in a "scene" to mean essentially the same thing as

Applicants mean by regions in a part of the data volume. For example, in a seismic data cube (3D data volume), the volume defined by two horizon surfaces might be a scene. An object could be used to represent a part of that scene, for example a salt body, a reservoir, or just a "bright spot" of unknown nature in the seismic data volume, which could be regions in Applicants' terminology. Many regions or objects could be usefully defined within the same scene. Further in the terminology of the present application, a region can be defined by one or more "constraints." For example, a region might be specified in a seismic data volume as those connected cells having seismic amplitude > 200.0 (to pick a number) and lying within two specified horizons. Logic expressions are convenient for expressing constraints. It is in this connection that Boolean logic enters into Applicants' invention. Applicants teach a constraint volume mapping function that may conveniently be defined by a user-based Boolean logic "truth table" (see paragraphs 26-28), and combine that with a mapping function defined for the original data set to produce a final texture memory transfer function. This allows a much more flexible region control display in which rendering of derived regions can be manipulated quickly without altering the values of the affected data components. Wentland teaches no such capability.

Wentland does disclose the use of Boolean operations, but in a significantly different connection than in the present invention. Wentland describes general Boolean operations (and arithmetic operations as well) that are applied to selected objects, i.e., directly to the data set. See paragraphs 843-844 and Figs. 38a and 38b.) See also Wentland's Abstract: "A personal computer is used to extract raw data and to perform Boolean operations at the behest of the user." Performing these operations on the data set is necessarily very costly for large seismic data volumes. By contrast, Applicants teach using Boolean logic only for creating a mapping function. The mapping table is then used to display manipulated regions, for example by modifying a color mapping table for selected volume region display. (In the terminology of Applicants' claim 1, desired derived regions are obtained from primary regions by manipulation of mapping functions.)

In Applicants' method, a separate data set called a constraint data set may be created only once from a given data set before the display operation. (See, for example, paragraphs 20-21.) After that, any Boolean expression combining a primary constraint for displaying a sub-region can be manipulated and displayed by merely modifying the mapping table. There is no costly Boolean operation directly to the data set. This is reflected in steps (b) and (c) of Applicants' claim 1. Wentland neither teaches nor suggests such use of Boolean operations. Furthermore, Wentland does not disclose Applicants' step (d) because this step depends on the preceding steps to make sense. In fact, Applicants do not find a disclosure in Wentland of Applicants' step (a), creating a constraint data set. Applicants would comment on specific passages in Wentland in regard to the steps of Applicants' claim 1, but Applicants note that no such specific citations are provided in the office action.

Following is Applicants' best interpretation of where in Wentland's method Applicants' method might be plugged in as an improvement, it being considered instructive to try to pinpoint what the user of Wentland's method has available to handle sculpting of the data volume. Wentland's paragraph 844 and Figure 38a clearly indicate combining objects with Boolean Operations, thus creating combined objects. This is also indicated in Fig. 37a at step **3730**. This is an example of a sculpting operation. It may not be indisputable in these places that Wentland means to apply the Boolean operator directly to the data, but that is made clearer elsewhere, for example in his Abstract. Alternatively, if Wentland is somehow trying to suggest Applicants' method, such an implication must fail as prior art for lack of enabling description. However, another passage in Wentland also makes it clearer that Wentland apparently envisions applying Boolean operators only directly to the data. See paragraph 515, which refers to step **1765** in Fig. 17a. Here, Wentland is merging scenes, another example of sculpting. He states, "This combination is performed using repeated Boolean operations applied to the objects in the scenes to create a union of the objects creating a single merged scene." Note that this refers to an existing option in what is apparently a commercially available software product called Chroma Vision, implying that patent publication US 2004/0098200 discloses no improvement over the prior art in this regard.

Applicants now wish to summarize what it appears that one would need to do to sculpt using the Wentland method. In order for each merged scene to be displayed, the Boolean operations are applied to the objects each time a new Boolean expression is described. That is, a new sculpted object needs to be created in order for the merged scene to be displayed accordingly. This conventional method of sculpting could clearly be improved by Applicants' method of creating a constraint data set as described in paragraph 20 and subsequent paragraphs in the present application. In this event, the operations to create the primary regions *(objects)* are applied only once, and the information is kept in the constraint data set. The Boolean expressions to define new constraints for the derived-region *(new merged scene, object)* from the primary regions can then be visualized without creating a new region (*a single merged scene, a combined object [figure 37a,step 3730]*). (Parenthetical insertions refer to the Wentland patent publication.)

More detail is provided by the following example. Let it be assumed that the four objects **3812**, **3814**, **3816** and **3818** in Wentland's Fig. 38a (see paragraph 844 also) are four primary regions in a scene data volume to be manipulated. If Applicants' method is used at this juncture, one can create a constraint four-bit volume to encompass the entire scene data volume. Each corresponding bit in the constraint data volume is used to denote the presence (Boolean 1) or absence (Boolean 0) of the objects in the scene, namely **3812**, **3814**, **3816** and **3818**. The derived object resulting from using the Boolean constraint expression ((Not 3812) OR 3814) OR (3820 AND 3808) can then be visualized by manipulating a true-false mapping table of 16-entries as described in paragraph 28 of the present application. Applicants find none of the preceding to be disclosed or suggested anywhere in Wentland. Even more telling is the fact that there is no need for the resulting objects **3820** and **3822**, clearly shown in Wentland's Fig. 38a, to be created if Applicants' inventive method were intended to be used in Wentland's process.

In the office action, the examiner appears to suggest that Wentland's templates and classifiers are equivalent to Applicants' constraints. It should be understood that Wentland describes a general multi-volume, co-rendering visualization tool, possibly

now currently available as an updated version of the commercial product Chroma Vision. Naturally, sculpting can be performed using such a general tool. Wentland states as much at paragraph 16. The issue is whether Wentland's tool contains the capability to perform sculpting in the improved, more efficient way disclosed by Applicants. Applicants contend that the answer to this is "no," and that instead sculpting must be performed with Wentland's tool in the traditional manner.

Thus, it can be seen that once superficial similarities are recognized as such, Wentland does not anticipate Applicants' claim 1, and in fact does not disclose a single step in such claim. The present application contains but one other independent claim (16). Its first three steps are identical to those in claim 1. Therefore, Wentland also cannot anticipate Applicants' claim 16.

CONCLUSION

Each of the claims of the application is limited to Applicants' inventive method for processing data sets. Each of these claims is believed to be patentably distinct from all known prior art, including U.S. patent publication No. 2004/0098200. Therefore, Applicants respectfully request allowance of all pending claims. If the examiner wishes to discuss this application with counsel, please contact the undersigned.

Respectfully submitted,

Date: *Aug. 4, 2005*

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